Modern Concepts of Cardiovascular Disease

Published monthly by the AMERICAN HEART ASSOCIATION

1790 BROADWAY AT 58TH STREET, NEW YORK, N. Y.

DR. THOMAS J. DRY, Rochester, *Editor*

DR. HOWARD B. BURCHELL, Rochester, *Associate Editor*

THE CHARLES DENISON MEMORIAL LIBRARY UNIVERSITY OF COLORADO SCHOOL OF MEDICINE

VOL. XVI APRIL, 1947 No. 4

VENOUS CATHETERIZATION IN CONGENITAL HEART DISEASE*

Recent years have seen the introduction of an operation for closure of the patent ductus arteriosus by Gross and Hubbard,[1] of operations for removal of the obstruction in the adult forms of coarctation by Crafoord and Nylin[2] and by Gross and Hufnagel[3] and of a procedure for the relief of the cyanosis associated with pulmonic stenosis by Blalock and Taussig.[4] These procedures offer relief or cure to patients with certain forms of congenital heart disease; the accurate diagnosis of congenital lesions, therefore, becomes of immediate and critical importance.

An informed judgment of physical signs, of measurements of blood pressure and of the roentgenologic findings will permit a correct diagnosis in many cases of the disorders mentioned. In a minority of such cases, however, these evidences are lacking or even misleading and other diagnostic procedures are needed. Catheterization of the cardiac chambers and the pulmonary artery[5, 6] may yield information applicable to the diagnosis of congenital heart disease.

In this procedure a catheter is introduced by way of the antecubital vein and its tip is placed successively, under the guidance of fluoroscopic observation, in the superior vena cava, the right auricle, the right ventricle and the pulmonary artery. The position of the catheter may be recorded by roentgenograms and appropriate observations made in each position of its tip. The information so obtained is of several varieties:

First, measurements of the pressures in the cardiac chambers and the pulmonary artery may be made. Normally the systolic pressure in the right ventricle and the systolic pressure in the pulmonary artery are essentially identical. If the pressure in the right ventricle is definitely and consistently higher than that in the pulmonary artery, this finding speaks strongly for the presence of pulmonic stenosis.

Consider, as an example, the case of a college student, twenty-two years old. He exhibited signs which could be interpreted as pointing to pulmonic stenosis or interventricular septal defect. Catheterization of the heart revealed, among other findings, the following: in the pulmonary artery a systolic pressure of 28 mm. of mercury and a diastolic pressure of 10 and in the right ventricle a systolic pressure of 65 and a diastolic pressure of 0.

The pressure in the pulmonary artery is in the upper range of the normal; the ventricular pressure is high; the difference points to pulmonic stenosis.

Second, determination of the oxygen content of samples of blood from the venae cavae, the right auricle, the right ventricle and the pulmonary artery give information concerning the entrance of oxygenated blood into the right side of the heart or the pulmonary artery. In a study of persons without congenital heart disease it has been found that when multiple samples of blood are obtained from different chambers, the greatest normal variation in maximal values for oxygen content between superior vena cava and right auricle is 1.9 volumes per cent, between right auricle and right ventricle 0.9 volumes per cent and between right ventricle and pulmonary artery 0.5 volumes per cent. Therefore, in any given case a rise of more than this amount indicates the entry of oxygenated blood into the chamber. Three examples will illustrate:

A woman of forty-three years presented progressive dyspnea and the syndrome of late cyanosis. There was some discussion as to whether these were due to atrial septal defect or to the so-called Eisenmenger's syndrome. Catheterization permitted the collection of samples of blood from the superior vena cava, the right auricle, the right ventricle and the pulmonary artery with the following results:

Blood from	Oxygen, vol. per cent
Superior vena cava	11.5
Right auricle:	
Sample 1	13.2
Sample 2	13.0
Sample 3	11.4
Sample 4	13.3
Sample 5	17.7
Right ventricle	13.2
Pulmonary artery	13.1

These figures offer evidence that arterial blood is entering the right auricle (note sample 5 from the right auricle), since the rise in oxygen content occurs in this chamber and not in the ventricle or pulmonary artery.

Similar reasoning may be applied to the interpretation of the following findings in a second patient:

Blood from	Oxygen, vol. per cent
Superior vena cava:	
Sample 1	13.1
Sample 2	13.4
Right auricle:	
Sample 1	12.6
Sample 2	13.5
Right ventricle:	
Sample 1	15.6
Sample 2	16.5
Sample 3	16.5
Pulmonary artery:	
Sample 1	16.1
Sample 2	16.1

*From the Medical Clinic, Peter Bent Brigham Hospital, and the Department of Medicine, Harvard Medical School, Boston, Massachusetts.

In this patient the rise in oxygen content is noted to be in the right ventricle, indicating the entry of arterial blood into that chamber by way of an interventricular septal defect.

In another patient the following figures were obtained for the oxygen content of blood from these several points:

Blood from	Oxygen, vol. per cent
Right auricle:	
Sample 1	13.8
Sample 2	13.7
Right ventricle:	
Sample 1	13.0
Sample 2	13.8
Pulmonary artery:	
Sample 1	14.6
Sample 2	15.1
Sample 3	15.3

These figures present clear evidence of a higher oxygen content in the pulmonary artery than in the right side of the heart, pointing to patency of the ductus arteriosus and to a flow of blood from aorta to pulmonary artery.

By having at hand certain additional data (the oxygen consumption per minute and the oxygen content of arterial blood in the left ventricle), it is possible to calculate the volume of the shunt, the flow through the lungs, the flow through the periphery and the output of each ventricle, all of which may throw light on the diagnostic and therapeutic decisions to be made.

Third, if the catheter has entered the pulmonary artery and then is permitted to move along the pulmonary artery until it fits tightly into the lumen of one of its branches, still another type of information may be obtained. If blood is now withdrawn it will usually contain an amount of oxygen representative of arterial rather than venous blood; that is, it is blood which has passed through the pulmonary capillaries and has come into contact with the alveolar air. If blood removed from a peripheral artery contains substantially less oxygen than this sample from a "pulmonary capillary" this constitutes evidence that venous blood is entering the arterial circulation.

For example in a young woman, twenty-nine years of age, cyanotic since birth, the following observations were made as to the oxygen content of blood from various vessels and chambers:

Blood from	Oxygen, vol. per cent	Saturation, per cent
"Pulmonary capillary"	27.6	97
Right pulmonary	20.4	
Pulmonary artery at bifurcation	19.8	
Right ventricle (average 2 samples)	20.4	
Right auricle (average 3 samples)	19.7	
Simultaneously from:		
Femoral artery	23.3	82
"Pulmonary capillary"	27.3	96
Breathing oxygen for 20 min.		
Femoral artery	23.8	84
"Pulmonary capillary"	27.9	98

The diminution in oxygen content and saturation of blood in the femoral artery as compared to that in the "pulmonary capillary" indicates that venous blood is entering the stream of oxygenated blood at some point; that is, that a right-to-left shunt exists. The insignificant rise in oxygen saturation of the blood in the femoral artery after inhalation of oxygen is evidence that unsaturation of arterial blood is not due to defective pulmonary ventilation or diffusion.

Calculations in accord with Fick's principles carry these observations further to show that the pulmonary blood flow in this patient was 2.3 liters per minute, the peripheral blood flow 4.7 liters per minute and the net shunt via the septal defect 2.5 liters per minute.

This procedure may thus be used in complex or unusual cases to assist in the recognition of patent ductus arteriosus, pulmonic stenosis, interatrial septal defect, interventricular septal defect and pulmonary hypertension. It may also give quantitative information as to volumes of shunts which may be useful in assessing the severity of the circulatory malfunction.

It is not a substitute for simpler methods of study but an addition to them to be used whenever required.

C. Sidney Burwell, M.D.
Lewis Dexter, M.D.
Boston, Massachusetts

REFERENCES

1. Gross, R. E. and Hubbard, J. P.: Surgical ligation of a patent ductus arteriosus. Report of first successful case. J. A. M. A. 112:729-731, (Feb. 25) 1939.

2. Crafoord, C. and Nylin, G.: Congenital coarctation of aorta and its surgical treatment. J. Thoracic Surg. 14:347-361, (Oct.) 1945.

3. Gross, R. E. and Hufnagel, C. A.: Coarctation of the aorta: Experimental studies regarding its surgical correction. New England J. Med. 233:287-296, (Sept. 6) 1945.

4. Blalock, Alfred and Taussig, Helen B.: The surgical treatment of malformations of the heart. J. A. M. A. 128:189-202, (May 19) 1945.

5. Cournand, A. and Ranges, H. A.: Catheterization of the right auricle in man. Proc. Soc. Exper. Biol. and Med. 46:462, (March) 1941.

6. Dexter, Lewis, Burwell, C. Sidney, Haynes, Florence W. and Seibel, Roy E.: Venous catheterization for the diagnosis of congenital heart disease. Bull. New England Med. Center, 8:113-121, (June) 1946.
Dexter, Lewis, Haynes, Florence W., Burwell, C. Sidney and others: Studies of congenital heart disease. III. Venous catheterization as a diagnostic aid in patent ductus arteriosus, tetralogy of Fallot, ventricular septal defect and auricular septal defect. J. Clin. Invest., in press.

NOTES

NOTES